

CHAPTER 1: PURPOSE, NEED, AND BACKGROUND FOR THE PROPOSED ACTION

Purpose of the Proposed Action

The purpose of this action is to reduce nitrogen oxides (NO_x) emissions by installing NO_x reduction systems for Units 1 through 9, at TVA's coal-fired Kingston Fossil Plant (KIF) in order to meet TVA's system wide NO_x reduction goal of 75,000 metric tons per year (83,000 tons/year) beginning in 2005.

Need for the Proposed Action

TVA must meet Title I CAA requirements for ozone for which NO_x is a precursor.

Background

The following discussion of NO_x air pollution and control technologies was primarily taken from *Pollution Engineering Online*, 1998.

Air Pollution from Nitrogen Oxides

NO_x emissions are a major factor in causing air pollution, including acid rain and high ground-level ozone concentrations. As recently as 1996, more than 50 million Americans were living in areas with unhealthy ozone levels. NO_x also plays a role in elevated levels of fine particulate, a pollutant, the effects of which the U.S. Environmental Protection Agency (EPA) is attempting to address by revising the National Ambient Air Quality Standards (NAAQS) to regulate concentrations of particulate matter with aerodynamic diameter of 2.5 microns or less (PM-2.5).

NO_x includes nitric oxide (NO) and nitrogen dioxide (NO₂), and is produced in motor vehicle and industrial combustion processes. These by-products form in three ways: when nitrogen in the fuel combines with oxygen in the combustion air (fuel NO_x), when fuel hydrocarbons break down and recombine with atmospheric nitrogen (prompt NO_x), and when the intense heat of combustion causes atmospheric nitrogen to combine with atmospheric oxygen (thermal NO_x). NO is a colorless gas that is converted in the atmosphere to yellowish-brown NO₂. NO₂ can cause adverse human health effects, including bronchitis, pneumonia, lung irritation and increased susceptibility to viral infection. Animal studies indicate that intermittent, low-level NO₂ exposures can also induce kidney, liver, spleen, red blood cell and immune system alterations.

NO_x emissions lead to the formation of ground-level ozone (photochemical smog), which has a strong negative impact on human health and the environment. Ozone impairs lung function and aggravates heart disease and respiratory diseases such as asthma and bronchitis. Ozone also impairs visibility and causes crop and forest damage.

NO_x reacts with oxygen and other components of air to form nitrates, which can coalesce into fine particles. Studies of collected PM-2.5 suggest that nitrates make up more than 10 percent of the mass of fine particulate in the western two-thirds of the country.

NO_x also contributes to the formation of acid rain. Acid rain has been shown to destroy fish and other forms of fresh- and coastal-water life, and to damage buildings and materials, forests and agricultural crops. In the eastern United States, NO_x emissions are responsible for about one-third of rainfall's acidity over the full year and one-half during the winter.

In 1994, national emissions of NO_x were 23.6 million tons. Electric utility and industrial fuel combustion contributed 9.7 million tons of NO_x, with an almost equal amount coming from mobile sources. Because so many Americans are exposed to smog, EPA regards ozone as a pervasive air pollutant. Analysis by the Ozone Transport Assessment Group (OTAG) shows significant NO_x reductions are necessary to solve the ozone non-attainment problem that affects many areas of the United States.

The control of NO_x came under intense government scrutiny with the passage of the Clean Air Act Amendments (CAAA) of 1990. Titles I and IV of the CAAA are directly applicable to the reduction of NO_x. Title I deals with the reductions in emissions of air pollutants to attain ambient air quality standards. Ambient ozone levels are the driving force for the installation of NO_x controls under this title. Title I of the CAAA also regulates the emissions of NO_x from municipal solid waste incinerators, both new and existing. Title IV is intended to reduce acid deposition. It primarily affects utility coal-fired boilers and cogeneration boilers with a 25 megawatts (MW) capacity or greater. Title IV of the CAAA requires a 2-million-ton reduction in coal-fired utility plant NO_x emissions by the year 2000.

In addition to the requirements for NO_x reduction derived from the CAAA, state, regional and local guidelines also set limits for emissions of NO_x from existing sources.

NO_x Control Technologies

Numerous technologies are used to control NO_x. These can predominantly be divided into two main categories: NO_x prevention and NO_x removal. Common prevention alternatives include low-NO_x burners and furnace modifications. Selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR) are typical post-combustion removal methodologies. A third type of control technology involves control of NO_x as it is formed during the combustion process within the boilers (e.g. NO_xTech).

Prevention Alternatives

In many cases, pollution prevention through the use of low-NO_x burners, overfire air or low-NO_x combustors is the most effective control approach. Low-NO_x burners can reduce NO_x emissions 20 percent to 60 percent compared to older generation burners. This NO_x control alternative generally has low to moderate capital equipment costs and low maintenance costs.

Furnace modifications such as overfire air, staged combustion and gas reburning can prevent the formation of NO_x. These modifications can include additional overfire air ports, which divert approximately 20 percent of the total combustion air to a secondary burning zone above the wind box, thus creating a fireball at or near stoichiometric air conditions. This extends the duration of the primary combustion zone so a greater portion of the devolatilization will take place before entering the fireball, thus reducing thermal NO_x production.

With gas reburning, natural gas is injected near the primary combustion zone to reduce the availability of oxygen. A significant portion of the NO_x precursors decompose and form other harmless nitrogen species. Overfire air is injected high enough in the furnace to allow sufficient residence time for the reburning reactions to reduce NO_x and its precursors and to complete combustion.

The major drawbacks of each of these technologies include their inability to meet required emission standards or future limits. And in some cases, as for cyclone burners or wet bottom boilers, these technologies may not be applicable. Further, low-NO_x burners also may increase the loss on ignition (LOI) content of the fly ash, increase furnace and water tube corrosion, lower boiler efficiency and increase particulate emissions.

Post-Combustion Removal

SNCR is a post-combustion chemical process for the removal of NO_x from combustion gases. A nitrogenous compound, typically ammonia or urea, is injected directly into the hot flue gases. At suitably high temperatures (1600°F to 2100°F), the nitrogenous compound decomposes and chemically reduces the NO_x to form molecular nitrogen and water. The temperature of the hot flue gases is the primary driving force for the reaction, and a catalyst is not needed. The efficiency of the chemical reaction depends on factors that include flue gas temperature, residence time at temperature, amount and type of nitrogenous reagent injected (ammonia or urea), mixing effectiveness and uncontrolled NO_x levels. Twenty percent to 40 percent reductions of uncontrolled NO_x levels are common. The two primary reagents used for the SNCR process are anhydrous ammonia and urea. Approximately 280 SNCR systems have been installed worldwide for a wide variety of industries. In the United States, commercial installations and demonstrations have included most boiler configurations and fuel types, as well as other major NO_x-emitting process units such as cement kilns. However, there is no experience on large (greater than 160 MW) boilers in electric utility service. In addition, SNCR operation can result in large amounts of ammonia slip (the emission of unreacted ammonia).

A variation of SNCR for NO_x control involves injection of ammonia and natural gas at controlled rates directly into the hot flue gases of the boilers. These technologies are typically proprietary. The technology has been successfully applied to small boiler units, but again the successful application for large generating units at the scale of KIF has not been demonstrated to date. Natural gas is also injected. Direct injection into the boilers can potentially reduce two factors making SNCR less desirable (discussed below), i.e. lower effectiveness in reducing uncontrolled NO_x levels (i.e. 20-40% reductions with SNCR), and larger amounts of ammonia slip. With direct injection of ammonia and natural gas into the boiler, higher levels of NO_x reduction and lower levels of ammonia slip can potentially be achieved. TVA is conducting a limited demonstration on one unit at its KIF from January to May 2002 in order to assess the feasibility of application for this technology.

SCR uses a catalyst to promote the chemical reaction between NO_x and a nitrogenous compound, generally ammonia, to produce molecular nitrogen and water. First patented in 1959, SCR is used to significantly reduce NO_x emissions from more than 250 sources in the United States. However, only a few of these sources are coal-fired boilers. There are more than 500 sources worldwide using SCR technology. In the United States, SCR

has been applied on utility and industrial boilers, gas turbines, process heaters, internal combustion engines, chemical plants and steel mills. Reduction levels of better than 90 percent are achievable with SCR, given the proper fuel, combustor and operating parameters.

In the SCR process, the catalyst allows the chemical reaction between NO_x and ammonia to occur at significantly lower temperatures (350°F to 1100°F) and with greater reagent utilization than does the SNCR process. An ammonia/air or an ammonia/steam mixture is injected into the combustion gas stream containing the NO_x . The gases are thoroughly mixed in a turbulent region, and then pass through the catalyst where the NO_x is reduced. The catalyst promotes the reaction but is not consumed by it. The catalyst's effectiveness lessens with time as its surface becomes contaminated with dust or trace elements from the flue gas. Several different catalysts are available for use at different gas temperatures. Base metal catalysts may contain titanium, vanadium, molybdenum or tungsten. Operating temperature ranges for base metal catalysts are between 450°F and 800°F. For higher temperatures, 675°F to 1100°F, zeolite catalysts have been used. For lower temperatures, 350°F to 550°F, catalysts containing precious metals such as platinum and palladium are preferred.

Tightened NO_x removal requirements have resulted in more SCR installations in the United States. Capital and operating costs have dropped rapidly over the past decade as a result of technological innovation, increased manufacturing expertise and competition among suppliers. Longer-than-expected catalyst lives have contributed to the reduced operating costs.

There is a concern about the use of SCR with high-sulfur fuels because sticky ammonium bisulfate can be deposited on the catalyst, air heater and other downstream surfaces. This compound is formed through the reaction of ammonia with sulfur trioxide (SO_3), which in turn is formed by the oxidation of the sulfur during the combustion process and then through the oxidation of sulfur dioxide (SO_2) by the SCR catalyst. By minimizing ammonia slip and suppressing the oxidation of SO_2 , the amount of ammonium bisulfate may be kept to a level that does not affect boiler operation.

Ammonia slip, the emission of unreacted ammonia, is caused by the incomplete reaction of injected ammonia with NO_x present in the flue gas. A system designed to achieve good distribution and mixing of the injected ammonia with the flue gas, as well as proper catalyst sizing and selection, will ensure ammonia slip is controlled to levels low enough that effects on plant operation, ash properties and health will be insignificant. The drawbacks of SCR technology include the difficulty of storing and transporting ammonia, the high capital cost of the catalyst, the difficulty of thoroughly mixing the injected ammonia in a turbulent zone prior to the catalyst, maintenance of the required reaction temperatures and disposal of spent catalysts.

SNCR and SCR may be used as a hybrid system. The SNCR process would provide a substantial portion of the NO_x removal and the SCR process would both control ammonia slip and perform the remaining treatment. A possible advantage of a hybrid SNCR/SCR system would be a reduction in capital cost since the amount of expensive catalyst required would be reduced. Additionally, combinations of SNCR and SCR may be installed on different units or families of units to achieve desired levels of plant total NO_x reduction.

Kingston Fossil Plant

KIF is located in Roane County, Tennessee, on the north bank of Watts Bar Reservoir (Figure 1-1). The plant is situated on a peninsula at the confluence of the Emory and Clinch Rivers. The nearest towns are Kingston at which the plant is located, and Harriman, about 5 miles to the northwest. The plant is on an 800 acre reservation, most of which is occupied by developed plant facilities.

KIF consists of 9 generating units with a total winter net generating capacity of 1450 MW. Kingston generates about 10 billion kilowatt hours (kWh) in a typical year, or enough electricity to supply up to 700,000 homes. Units 1 through 4 have a nameplate rated capacity of 135 MW each; and Units 5 through 9 have a nameplate rated capacity of 180 MW each. Depending upon unit, commercial operations began between February 1954 and December 1955. Units 1 through 4 are natural circulation, reheat-type radiant boilers; Units 5 through 9 are twin furnace, reheat-type with controlled circulation.

About 3.8 million tons of medium sulfur coal is annually mined and transported to Kingston by rail, mainly from mines in Eastern Tennessee and Eastern Kentucky. Modifications (EPRICON) are currently being made to enable the station to utilize low sulfur coal from Virginia and West Virginia, and are expected to reduce sulfur emissions by 30%. Along with 1000 foot stacks, high efficiency (99.67% efficient) electrostatic precipitators installed in 1975-77 have traditionally been used to control particulate emissions at KIF. Low-NO_x burners were installed on Units 5-8 in 1998-1999 to reduce the emission of potential contributors to ozone and regional haze formation.

Related National Environmental Policy Act (NEPA) Documents

NEPA Documents prepared by TVA related to the KIF are listed below.

Energy Vision 2020 - Integrated Resource Plan. Environmental Impact Statement. Tennessee Valley Authority. December 1995.

Kingston Fossil Plant Alternative Coal Receiving Systems - Final Environmental Impact Statement. Tennessee Valley Authority. January 1997.

Kingston Fossil Plant Alternative Coal Receiving Systems - Final Supplemental Environmental Impact Statement. March 1999.

Scoping Process

A TVA interdisciplinary team reviewed the potential direct and indirect effects of the proposed use of SCR or NO_xTech systems at KIF for NO_x control. From this review the following project aspects potentially result in impacts and were consequently identified for detailed analyses.



Figure 1-1. Location of Kingston Fossil Plant.

- Beneficial effects to air quality from reducing NO_x emissions
- Contamination of coal combustion by-products with ammonia
- Contamination of chemical pond, and ash pond with ammonia
- Wastewater and impacts to surface water quality from ammonia in pond discharges
- Public and worker safety issues related to the storage and handling of anhydrous ammonia
- Effects of constructing and operating a natural gas supply pipeline
- Socioeconomic effects of the project related to increased jobs.

In this Environmental Assessment (EA) potential construction and operational impacts to the following resource areas were the bases for the evaluations: air quality; ammonia storage and handling; terrestrial ecology; wetlands and floodplains; land use; visual aesthetics and noise; archaeological and historic resources; solid and hazardous waste; aquatic ecology; wastewater; surface water quality; ground water quality; socioeconomics; and transportation.

Public and Agency Involvement

In August of 2001, TVA held a public information scoping session in Kingston, TN. Environmental issues raised in comments included safety with regard to delivery and storage of anhydrous ammonia and air and water quality impacts.

In April 2002, the EA was placed on the TVA web site and a news release made regarding availability of the EA. This release informed interested persons that copies of the EA were available by requesting a copy from TVA staff in Environmental Policy and Planning, Knoxville, Tennessee. Copies of the EA were placed in public libraries in Kingston and Oak Ridge, Tennessee, as well as the main TVA Corporate library in downtown Knoxville, TN.

In April 2002, copies of the EA were sent to the Tennessee Department of Environment and Conservation (TDEC), and the U.S. Fish and Wildlife Service. Coordination with the Tennessee Historical Commission under Section 106 of the National Historic Preservation Act (NHPA) was completed in January 2002 (Appendix B).